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BY AERIAL PLANTING-..(U) NATIONAL AERONAUTICAL
ESTABLISHMENT OTTAWA (ONTARIO) A D WOOD FEB 83

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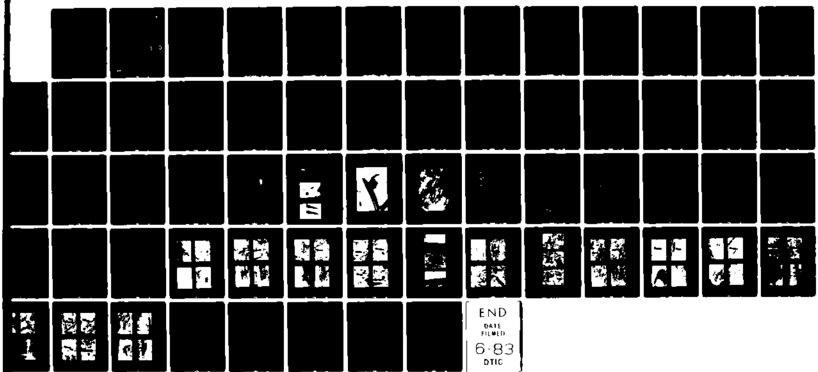

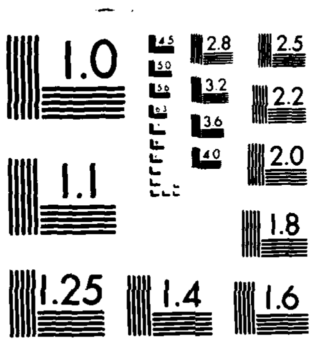

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

UNLIMITED
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EXPLORATORY FIELD INVESTIGATION OF GROUND PENETRATION BY AERIAL PLANTING-DARTS AND SUBSEQUENT GERMINANT SURVIVAL

ÉTUDES PRÉLIMINAIRES SUR LE TERRAIN DE LA PÉNÉTRATION ET DE LA SURVIE ULTÉRIEURE DE SEMIS EN TUBES (DARDS) PLANTÉS PAR AÉRONEF

by/par

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National Aeronautical Establishment

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AERONAUTICAL NOTE
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ABSTRACT

The ability of aerial planting-darts to penetrate the ground and the subsequent survival of germinants have been investigated through air-drop tests conducted at various dissimilar sites.

The results indicate that there is a range of penetration within which darts may be considered as suitable candidates for the establishment of seedlings. Given some discretion in the selection of sites for aerial planting, it now appears reasonable to expect at least half the darts to achieve penetration within this range. The ultimate success, in terms of darts occupied by at least one surviving seedling, will then depend upon additional factors such as the depth of the mineral soil horizon below the ground surface, the presence of vegetation, the time of year and the prevailing weather.

Vigorous seedlings have been established by air-drops at some sites. Overall success rates are not, as yet, adequate, but the results have demonstrated the potential of the aerial planting technique and indicated some of the most promising avenues for further investigation and testing.

RÉSUMÉ

Des essais de plantation aérienne ont été effectués en plusieurs endroits différents afin d'étudier la pénétration et la survie ultérieure de semis en tubes (dards).

Les résultats obtenus indiquent qu'il existe une certaine zone de pénétration dans laquelle les dards pourraient s'avérer appropriés à l'établissement de semis. Si les endroits pour la plantation aérienne sont choisis avec discernement, on peut raisonnablement prévoir qu'au moins la moitié des dards se trouveront dans cette zone. Le succès ultime de l'opération, déterminé par le nombre de dards donnant naissance à au moins un plant viable, sera fonction d'autres facteurs comme la profondeur de l'horizon minéralisé, la présence de végétation, le moment de l'année et les conditions météorologiques.

Des semis vigoureux ont pu être établis par plantation aérienne dans certains endroits. Le taux de succès global n'est pas encore approprié, mais les résultats obtenus ont démontré de bonnes possibilités pour la plantation aérienne et ont indiqué certaines des approches les plus prometteuses pour la poursuite de la recherche et des essais.

CONTENTS

ILLUSTRATIONS (Cont'd)

The characteristics of the sites made available are summarised in Table I.

Several of the sites in the Aubrey Falls area referred to in this report were also included in a short program carried out jointly in that area with staff of the Great Lakes Forest Research Centre of the Canadian Forestry Service, who made additional observations and measurements on the ground.

4.0 Equipment and Procedures

4.1 Dart

The dart configuration used in this program is illustrated in Figure 1. Darts dropped at the various sites differed from one another only in the quantity and composition of the contents. The average empty weight of each dart, comprising the paper cone, heavy, shaped, plastic nose-cap and interior plug, amounted to 11.8 g. The weight of the contents increased from 4.5 to 6 g as the quantity of soil mix loaded was increased during the program.

The basic soil mix chosen was one which had demonstrated favourable characteristics during a preceding program of greenhouse tests carried out at the University of Toronto. Its composition is given in Table II, together with other constituents of the dart "payload". Table II also indicates the loading sequence followed during the program and identifies notable variations.

The perlite or vermiculite layer, added as the final step in the loading schedule, served to fill the cavity in the tail-cone of the dart with a light-weight material and was intended to prevent significant disturbance of the contents during handling prior to use in the field.

The compressed peat pellets were introduced as a measure to increase the effective volume of the dart contents after impact. The pellets expand after absorbing water. It was also thought that this material might have

a favourable effect in terms of moisture retention during the germination period.

To prevent premature germination in darts being stored for several weeks before the field tests, unstratified seeds were used and the basic soil-mix was oven-dried to reduce the moisture content to less than 5 per cent.

Figure 2(a) is a photograph of darts used in the program. In most cases a light-weight, plastic streamer was attached, as shown, to improve conspicuity on the ground. The transverse markings on the other dart are 1 cm apart.

Figure 2(b) illustrates the normal paths followed by the escaping radicle and lateral roots in darts of this type.

Figure 2(c) is a photograph of a typical seedling from darts identical with those used in the field tests, but in this case grown in a sand-filled pot under artificial light.

4.2 Dispenser

In meeting the major objectives of the 1982 program, there was no necessity to distribute darts along a lengthy flight-path, which would unnecessarily increase the difficulty of the subsequent search and ground monitoring. Instead, the procedure adopted required the helicopter to hover above selected target sites. Clusters of darts, typically 25, 50, 75 or 100 in number, were then released. The dispersion normally present automatically provided a random sampling of the site over an area with a typical dimension of, perhaps, 20 ft.

The dispenser constructed for this task was, thus, quite simple, as shown in Figure 3. It consists of a box in which up to 104 darts may be accommodated. The darts are oriented vertically and separated from each other by a grid of partitions. Hinged doors under each row of darts are actuated simultaneously from the cockpit by a lever and cable system.

:ures

!itate comparisons, a nominal drop height .e target site was used for all field tests. re used to designate the aiming point and positioned with the assistance of instructions io from a ground observer located opposite eral hundred feet to one side. With some cedure resulted in acceptably small errors.

r each drop, darts were located and marked rds (floor tiles) and the resulting drop ly photographed from the helicopter using a ed, 70 mm camera (Fig. 4).

ring

s temporary measure, the flat marker at laced by a stick with flagging-tape. A plastic ng the drop number and date was also placed for use in identifying photographs. art penetration and inclination were recorded each drop. Subsequently, visits were made ng the remainder of the growing season to raph emerging and developing seedlings and in the characteristics of the sites within

of precipitation and of maximum and minimum s for the season were obtained from the stations. At Kemptville such measurements mile of the drop sites. At Petawawa the is approximately 3 miles from the drop site. . Laurier the nearest observing station is ile for sites in the Aubrey Falls area the earest observing station at Peshu Lake is 7 miles.

These records are presented in Figures 5 to 8. The dates on which various drops were made are also indicated at the bottom of these figures.

5.0 Results

5.1 Penetration of the Ground

Figures 9 to 13 present the observations of penetration obtained at nine sites having the characteristics summarized in Table I. Since the observable parameter is the axial length of fin remaining exposed above the ground surface, penetration is expressed in terms of "fin exposure". The corresponding submerged length is illustrated by the transverse lines in Figure 2(a).

The penetration achieved at the three Kemptville sites, used for initial testing, is apparent in Figure 9. At Site 1 (see also Fig. 14) only 12 per cent of the darts penetrated to the preferred range with a fin exposure of between 0 and 2 cm. Another 34 per cent fell in the range between 2 and 4 cm, while 18 per cent were in the range 4 to 5 cm. The remainder, 36 per cent, had totally inadequate penetration, generally as a result of striking obstructions (stones) on or below the surface. The terms "preferred", "shallow", "marginal" etc. associated with various ranges of fin exposure are somewhat arbitrary, since they pre-suppose a relationship between penetration and the prospects for seed germination and seedling survival. Subsequent observations, however, discussed in Paragraph 5.2, provide broad justification for the terminology adopted.

The results obtained at Sites 2 (see also Fig. 15) and 3 (see also Fig. 16) differ markedly from those at Site 1. Both of these sites were reverting to heavy vegetation, whereas Site 1 had no vegetation when the darts were dropped. The presence of vegetation increases the difficulty in locating darts and some remain undiscovered. Consequently the results are shown as percentages both of the number of darts located and and of the number of darts dropped.

and Petawawa, where the depth of the mineral soil horizon at the selected sites is considerably smaller. With this reservation, Figures 9, 10 and 11 give a first indication of the effect on dart penetration of a variety of surface and sub-surface characteristics.

For comparison, Figures 12 and 13 show penetration distributions obtained at three sites near Aubrey Falls, approximately 50 nautical miles south of Chapleau, Ontario. Site F (Figs. 12 and 24) is a small area subjected to a prescribed burn in 1981. The distribution has similarities with those obtained at Petawawa (Fig. 10) and Mont Laurier (Fig. 11). The site is sandy with an overlying, partially-burned, organic layer.

Site C (Figs. 13 and 27(a)) is an area which has been wind-rowed and scarified for ground planting.

Site B (Figs. 13 and 27(b)) is an unscarified, debris-covered area, which has remained untreated since being logged several years ago.

It is evident that the removal of some of the surface debris by windrowing and scarification greatly reduces the number of losses which occur when darts strike obstacles. The number of cases of inadequate penetration falls from 53 per cent at Site B to 22 per cent at Site C. It also appears that the ground is softer at Site C, possibly as a result of scarification.

In addition to penetration, dart inclination after impact is a parameter of some concern, since an excessive inclination could adversely affect the prospects for seedling establishment, as discussed further in Paragraph 5.2. It was noted, however, that instances of dart inclination greater than 45 deg. from vertical were rare and that large angles of inclination, when they did occur, were associated with inadequate penetration. Conversely, darts achieving substantial penetration of the ground were generally associated with inclination angles

much less than 45 deg. This qualitative observation is regarded as applicable to the results presented here for all values of fin exposure less than 4 cm.

5.2 Germination and Survival

5.2.1 Weather Records

Figures 5 to 8 show the timing of drops at the various field test sites in relation to daily temperature fluctuations and the occurrence of precipitation. For the 1982 growing season the following general comments may be relevant:

a) the maximum temperature records for Kemptville, Petawawa and Mont Laurier do not differ greatly from one another;

b) somewhat higher maximum temperatures occurred at Peshu Lake for appreciably longer periods, particularly in June and July, when daytime temperatures frequently exceeded 30°C;

c) these higher daytime temperatures at Peshu Lake were accompanied by lower temperatures at night;

d) precipitation amount was greatest and its frequency most uniform at Kemptville. Petawawa often experienced very light showers but also relatively dry periods of at least a week's duration in May, June, July and August;

e) precipitation at Mont Laurier was particularly scarce in July. At Peshu Lake lengthy dry periods occurred in June and July.

5.2.2. Qualitative Observations

Figure 14 illustrates the results of a drop made in late April at Kemptville, Site 1, where the bare soil was rapidly drying following the spring thaw. In this figure, photographs (a) and (b) indicate the area sampled by a drop and the method of marking and labelling a typical sealed dart immediately after impact. Photograph (c) shows another typical

For the air drops made at Kemptville, quantitative data points are plotted in Figure 28. Observations continued at Sites (2) and (3), but not Site (1), until late October. The relatively small change in percentages of darts occupied by seedlings during the preceding four months is noteworthy. Although only qualitative observations were made during the period when germination was taking place, it is assumed that the tentative interpolations shown by dashed lines would bear some resemblance to the numerical facts.

Of particular interest in this figure is the value (84 per cent) achieved at Site (1) eight weeks after the drop and just before the site was reclaimed for other uses. If the subsequent mortality at this site had followed a trend similar to those exhibited at Sites (2) and (3), more than 75 per cent of the candidate darts would have been occupied by seedlings in late October.

At Petawawa, despite some individual cases of darts with exceptionally vigorous seedlings, as illustrated in Figures 19 to 21, the percentages of occupied darts were lower than those at Kemptville. Figure 29 shows the results obtained for both Jack Pine and White Pine at this site. Referring to the cumulative precipitation record, it is evident that the drops were made during a comparatively dry period. Germination was probably accelerated by considerable precipitation about three weeks later. A dry period of nine days duration followed, after which there was again significant precipitation before further dry periods in June, July and August. Some mortality shortly after germination was observed and hence the curves are thought to have peaked in a manner somewhat as shown. For White Pine, subsequent mortality during the summer months was observed to be greater than that for Jack Pine.

As already indicated in Paragraph 5.2.1, the combination of late drop dates, dry, hot weather and a deep organic layer contributed, it is thought, to the poor record of growth at Mont Laurier, shown in Figure 30. The sites were revisited,

the short period of vulnerability before a primary root is in contact with mineral soil, may arise with air-drops carried out in the late Fall. With this choice of season, the darts would remain in a dormant condition until the following Spring.

6.0 Concluding Remarks

The exploratory field tests which have been described in the preceding paragraphs have provided opportunities for both qualitative and quantitative observations of aerial planting-darts in a variety of situations. Measurements of penetration of the ground surface by darts dropped at dissimilar sites have given a first indication of the magnitude of the variations in penetration to be expected and of the interference caused by stones, debris or other obstructions. Where the mineral soil horizon is close to the ground surface, as at the Kemptville sites, seedlings have been established in darts having between 0 and 4 cm of fin length exposed after impact and with inclinations of up to 45 deg. from the vertical.

Where the mineral soil horizon is separated from the ground surface by a layer of organic material, maintaining the greatest possible penetration of this horizon by minimizing the fin length exposed above the ground surface is evidently advantageous. Complete submergence of the fins below an ill-defined surface may lead to seedling establishment provided that the surrounding material does not prevent partial opening of the fins. Since the paper cone is just under seven cm in length and its forward end should preferably be in contact with mineral soil, darts are less likely to be effective in the presence of organic layers with a depth of more than about five cm. The field test results support this contention.

Seeds contained in air-dropped, planting-darts have successfully established seedlings (Jack Pine and White Pine) at various sites. Some particularly vigorous examples developed at Petawawa. At Kemptville, Jack Pine seedlings survived their first growing season in the presence of strong competition from site vegetation. The accompanying shade, by providing protection

from heat and dryness, appeared to offset the unfavourable effects of competition during this period. Seedlings were also successfully established in moss clumps penetrated by planting-darts.

In the Aubrey Falls area some seedlings were established at burned sites. Manual plantings at the same location gave particularly good results, indicating that burned areas should be the subject of special attention in any further air-drop tests.

Given some discretion in the selection of sites for aerial planting, it now appears reasonable to expect the penetration of at least half of the darts to be in the range required to make them suitable candidates for the establishment of seedlings. Achieving or exceeding this figure in typical operational areas, however, may require such measures as modest, but practical, increases in dart weight or drop height.

Thereafter, germination and survival will depend upon the more detailed characteristics of the site, the appropriateness of the timing and the weather. The first eight-week period appears to be the most critical from the standpoint of mortality. Hence, the probability of prolonged dryness or heat at this stage should be minimized by dropping as early as possible in the Spring. Alternatively, air-drops in the late Fall, before the ground becomes frozen, are worth consideration as a means of promoting early growth in the Spring.

Finally, the vulnerability of planting-darts to heat and dryness may be reducible either by improving their moisture-retention properties or by shortening the time required for developing roots to reach mineral soil. Water-absorbing polymers, used as additives to the growth medium, represent one possible approach to improved moisture retention and could well form part of a more thorough attempt to optimize growth medium constituents. Accelerated growth, through the use of biological agents would, if practical, shorten the time for primary root establishment in mineral soil.

the course of the program very little inter-
ts or rodents was observed. No significant
n seedling growth attributable to dart materials
reliminary laboratory tests or in the field
lease performance was regarded as satisfactory.
of completed darts it was necessary to re-seal
premature release of the tape during storage.
lieved to be associated with humidity conditions
application. Closer environmental control at
manufacture is the most likely solution.

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or is indebted to numerous persons and organiza-
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pany of Buckingham, P.Q. and the Département
urces, Quebec for making available sites in the
ont Laurier.

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Lakes Forest Research Centre (GLFRC) of the
Service and were used with the permission of
ry of Natural Resources. The support provided
. L.F. Riley, Mr. J. Richenhaller, Mr. R. Folk
aff who participated in the joint program, is
ciated, since the successful development of
technique will continue to require a convergence
from within and outside the field of forestry.

rying out preliminary greenhouse tests at the
ronto to establish the suitability of various
consideration, Dr. J.L. Farrar of A.D. Revill
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Support of various kinds provided by colleagues is implicit in any project undertaken by the Flight Research Laboratory and the present example is no exception. The author wishes to acknowledge with thanks such support and to mention particularly that of Mr. Brian Usher and his staff, in the preparation of equipment, as well as that of Mr. Clark Isenor. In addition to his normal helicopter maintenance activities, the latter has spent many hours assisting the author in field work of a type with which both, at the outset, were equally unfamiliar, but which, hopefully, has not suffered unduly in consequence.

8.0 References

1. Wood, A.D. Brief Outline of an Aerial Planting Concept for Forestry Applications. National Research Council NRC NO. 19782, NAE Aeronautical Report LR-607, October 1981.

TABLE I

SUMMARY OF TEST-SITE CHARACTERISTICS

Kemptville, Ontario

Site 1	Bare, loamy-sand with numerous stones. Weed-controlled by cultivation Fall 1981.
Site 2	Natural hardwood, clear-cut 1979 and brush removed. Reverting to heavy vegetation. Well-drained, sandy-loam. Little organic material.
Site 3	Mixed conifer/hardwood, clear-cut 1980 and brush removed. Less uniform but otherwise similar to Site 2.

Petawawa, Ontario

Site 3	30-year old Scots Pine Plantation, clear-cut 1981 and brush removed. Smaller litter remaining. Sprayed with 2-4-D July 1981.

Mont Laurier, Quebec

Site 2	Mixed conifer/hardwood, clear-cut and brush partially removed. Organic layer above sand. Surface materials, including remaining brush, inter-mixed by scarification.
Site 3	Primarily Black Spruce, clear-cut and brush mainly removed. Thick, undisturbed organic layer above sand. Reverting to coarse vegetation (e.g. blueberry).

Aubrey Falls Area (Mississagi River South of Chapleau, Ontario)

Site F	Mixed conifer/hardwood subjected to prescribed burn 1981. Reverting to vegetation. Partially-burned organic layer above sand.

Sites also included in Joint GLFRC/NRC Program:

Site A	similar to Site F, but burned 1982.
Site C	scarified area between wind-rows.
Site B	unscarified area, clear-cut but brush remaining.

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II

SCHEDULE

2 ml	(Metromix 200:Silica Grit #40, 4:1 by vol.)
.6 ml	(NPK % Content 12.6:6.6:15.6)
4 ml	Kemptville (Jack Pine), Petawawa (White Pine)
5 ml	Petawawa (Jack Pine)
6 ml	Mont Laurier and Aubrey Falls
2	Kemptville (Jack Pine), Petawawa and Mont Laurier (White Pine)
3	Petawawa, Mont Laurier and Aubrey Falls (Jack Pine)
0 ml	Kemptville and Petawawa
1 ml	Mont Laurier and Aubrey Falls
2 ml	Kemptville and Petawawa
2 ml	Mont Laurier and Aubrey Falls

d to 5% Moisture Content

PAPE

GROWTH MED

BALLAST

NOSE (

GROWTH MEDIUM VOL: 9.6
EMPTY WEIGHT: 11.8
TYPICAL GROSS WEIGHT: 16.

FIG. 1: AERIAL PLANT

FIG. 4: AERIAL PHOTOGRAPH OF TYPICAL DROP PATTERN. (BURNED SITE)

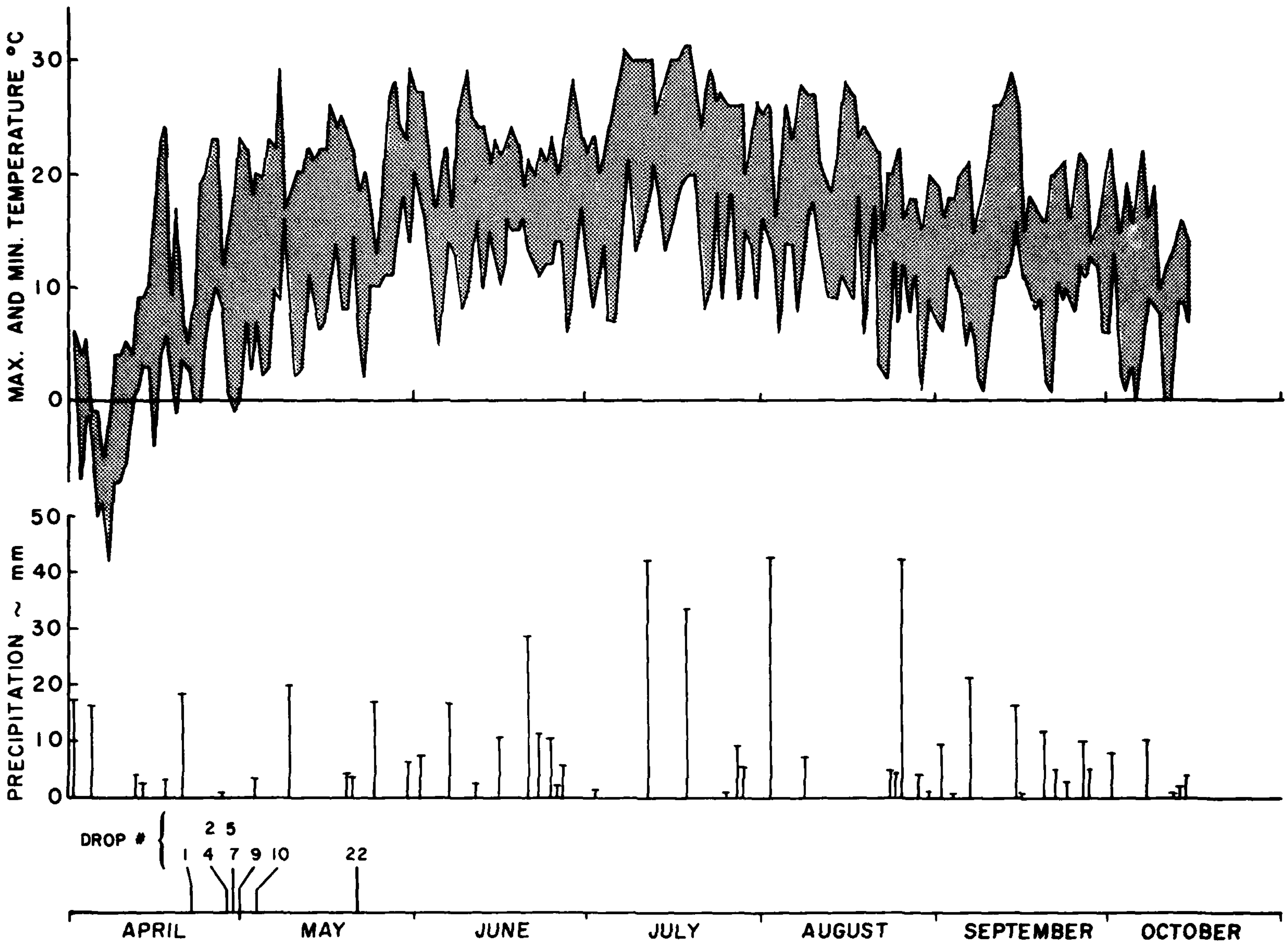


FIG. 5: KEMPTVILLE ~ MAX/MIN TEMPERATURES AND PRECIPITATION

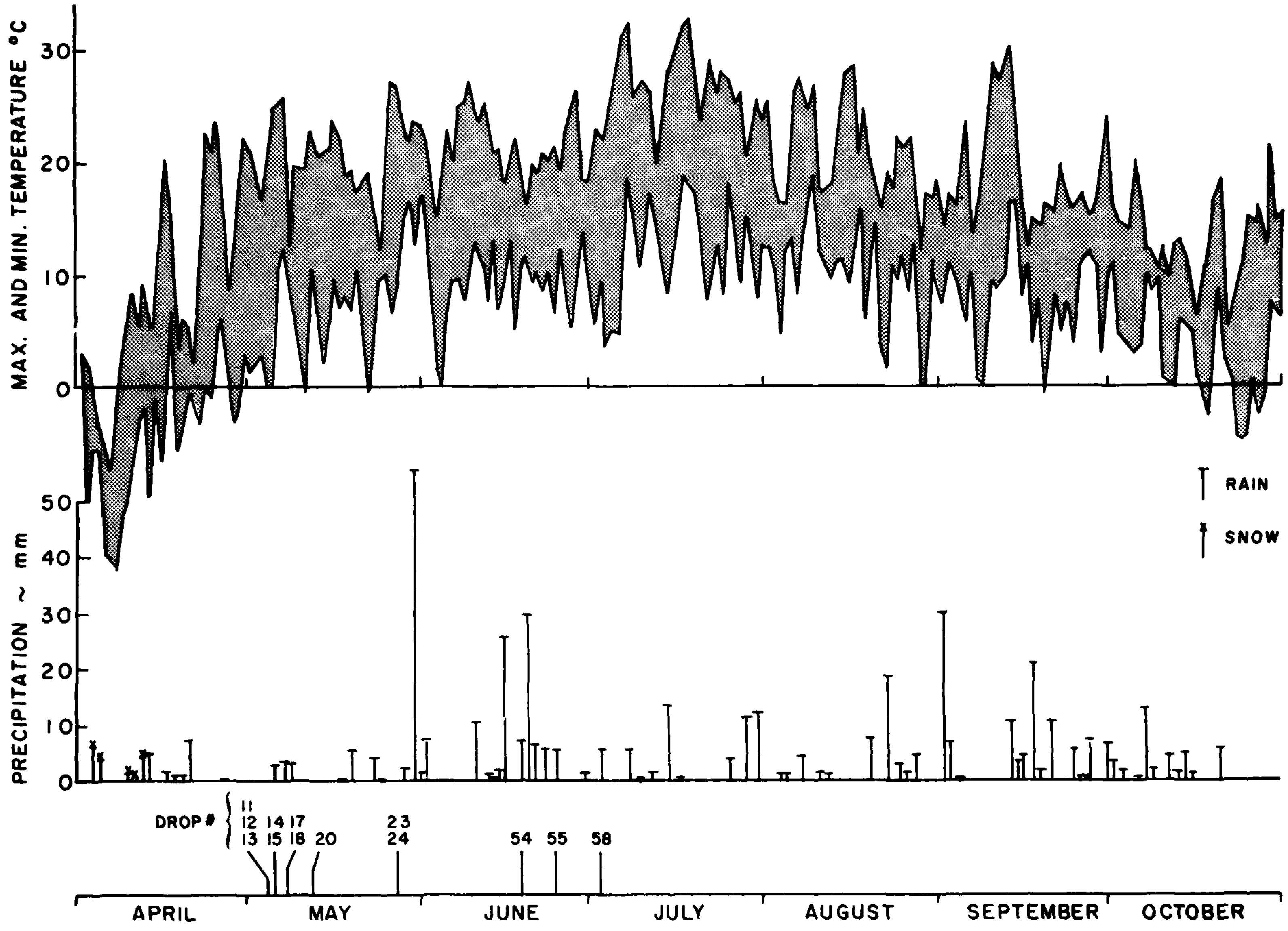


FIG. 6: PETAWAWA ~ MAX/MIN TEMPERATURES AND PRECIPITATION

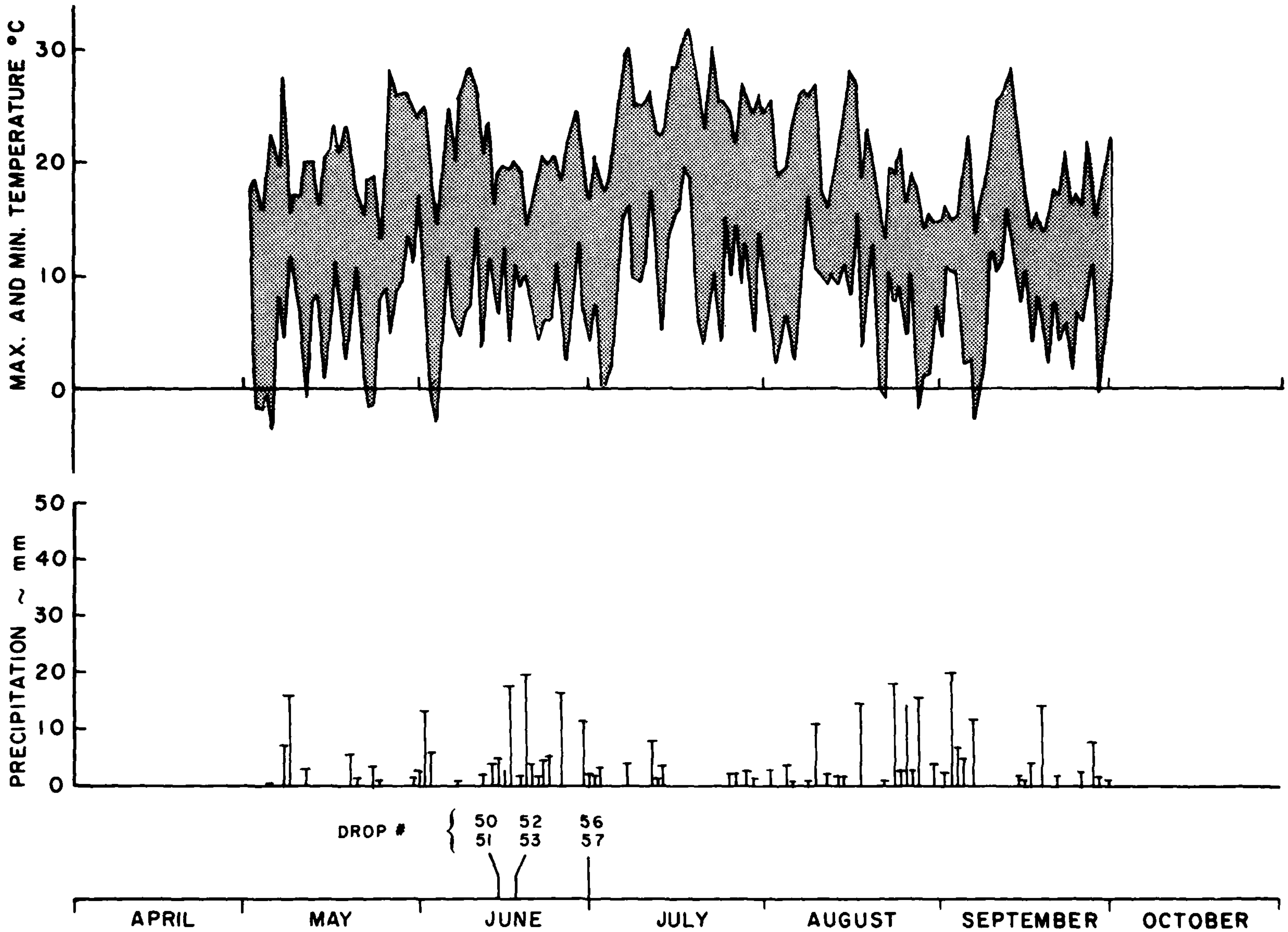


FIG. 7: MT. LAURIER ~ MAX/MIN TEMPERATURES AND PRECIPITATION

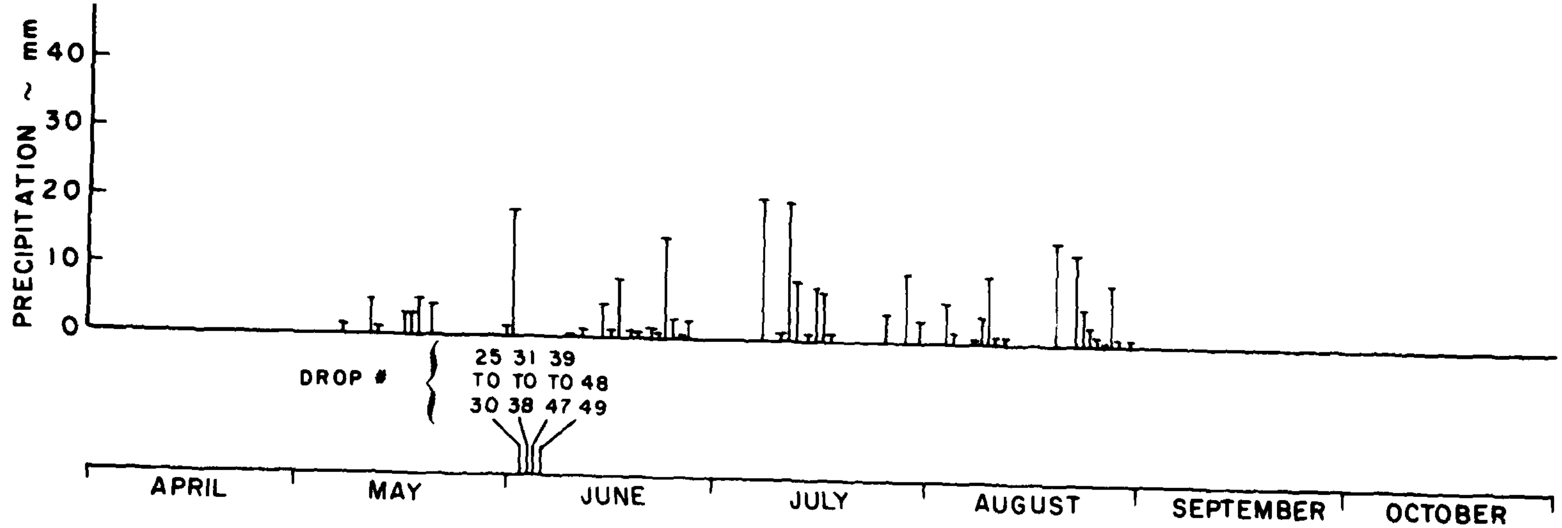
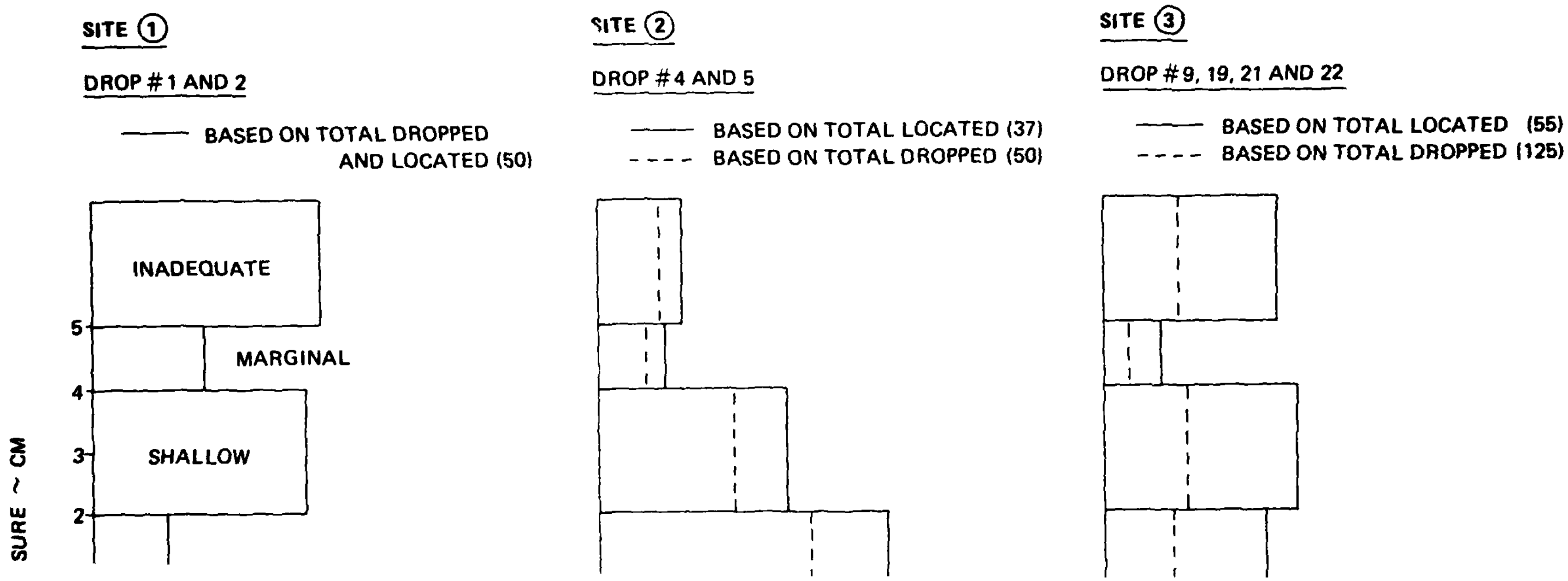


FIG. 8: PESHU LAKE ~ MAX/MIN TEMPERATURES AND PRECIPITATION



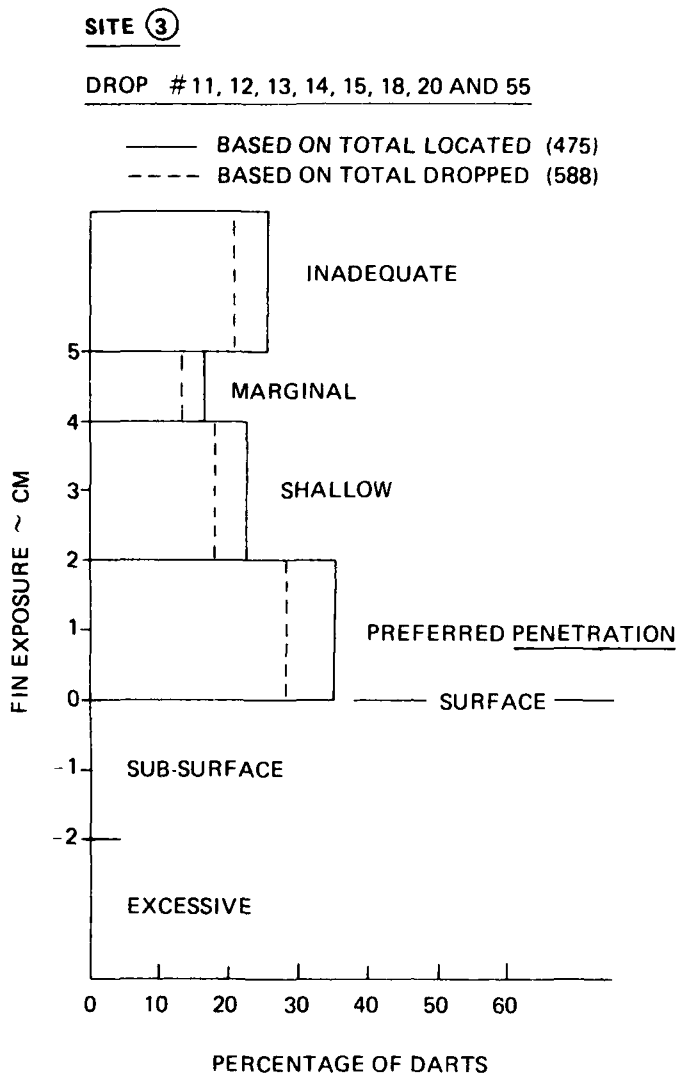


FIG. 10: PETAWAWA SITE 3. PENETRATION (FIN EXPOSURE) DISTRIBUTION

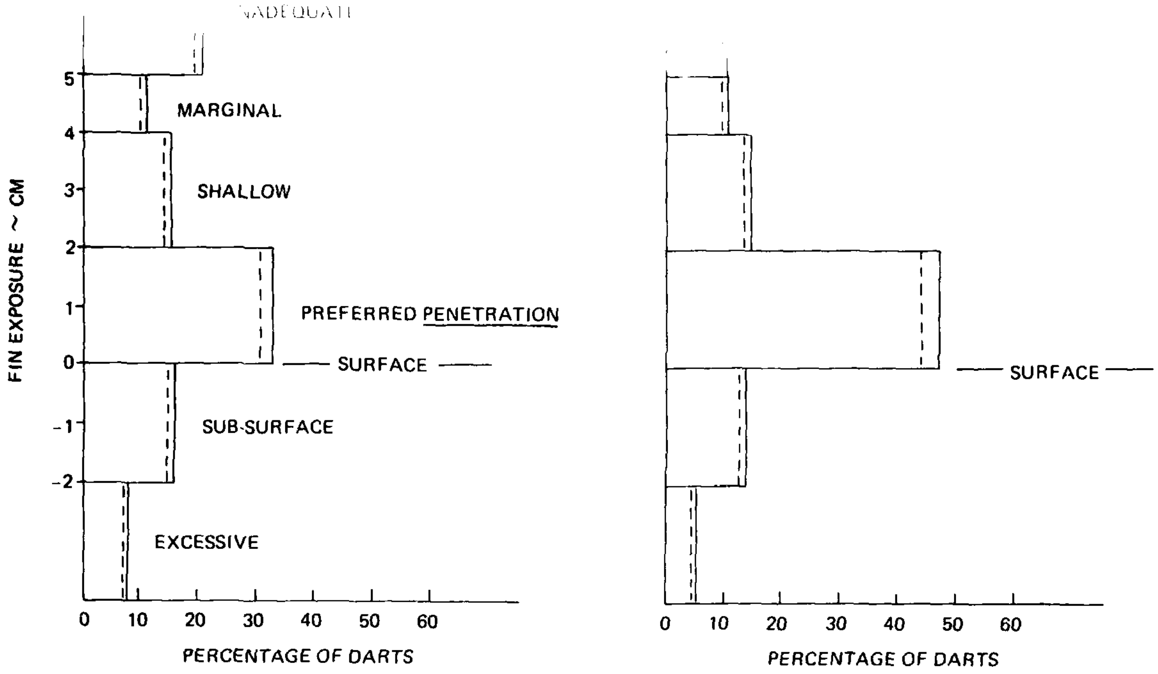


FIG. 11: MT. LAURIER. COMPARISON OF PENETRATION (FIN EXPOSURE) AT TWO DISSIMILAR SITES

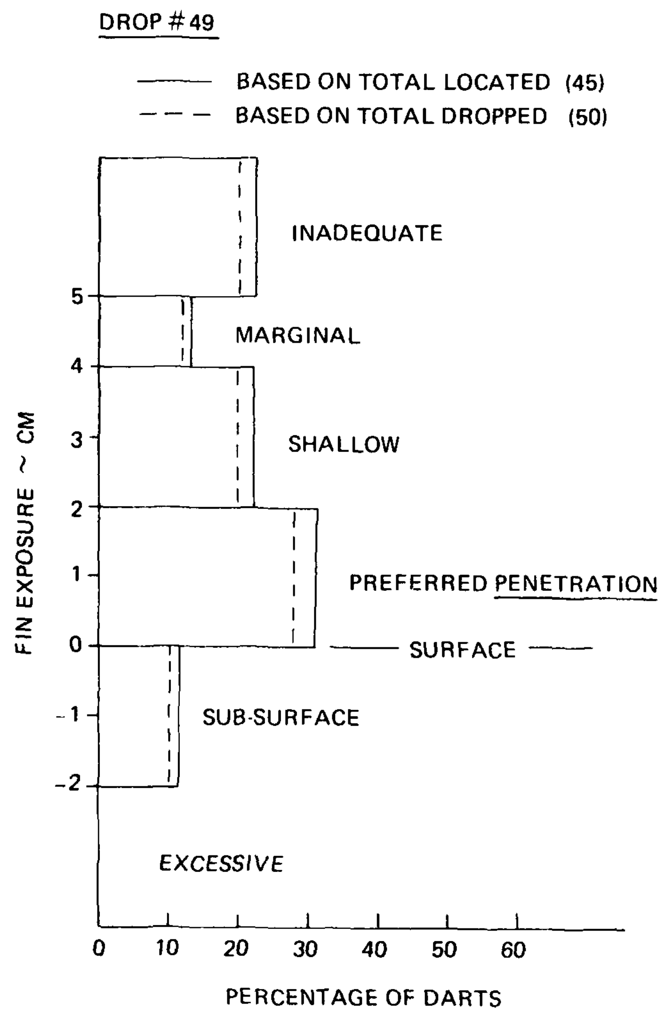


FIG. 12: AUBREY FALLS AREA, SITE (F) (1981 BURN). PENETRATION (FIN EXPOSURE) DISTRIBUTION

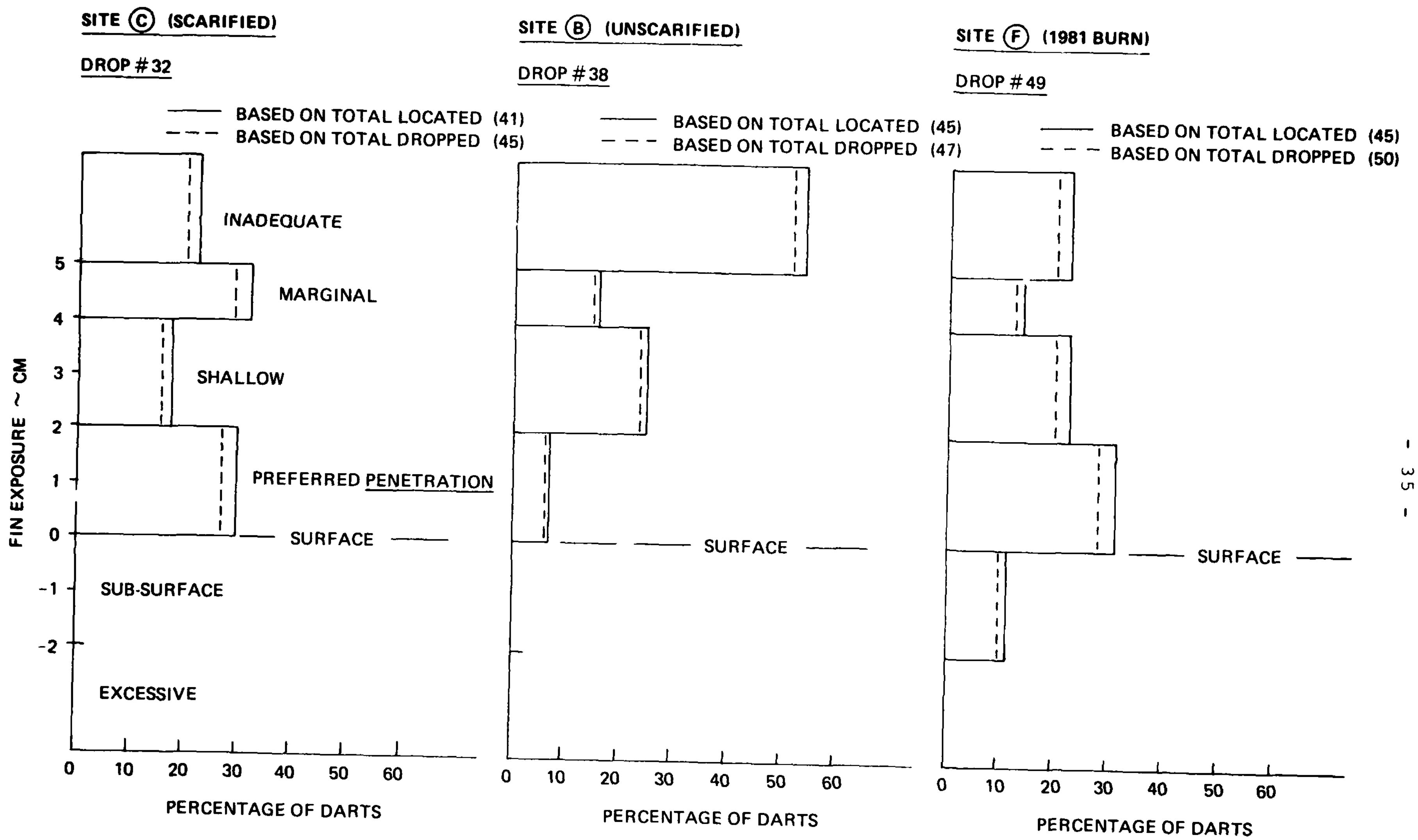


FIG. 13: AUBREY FALLS AREA. COMPARISON OF PENETRATION (FIN EXPOSURE) AT THREE DISSIMILAR SITES

(a) DROP ZONE (PHOTO 28.4.82)

(c) TYPICAL DART (PHOTO 10.5.82)

(b) TYPICAL DART (PHOTO 28.4.82)

(d) SAME DART AS (c) (PHOTO 23.6.82)

FIG. 14: KEMPTVILLE SITE 1 . SITE CHARACTERISTICS AND TYPICAL DARTS.
DROP NO. 2 – DROP DATE: 28.4.82

(a) DROP NO. 9. DART G (PHOTO 14.10.82)

(c) DROP NO. 10. DART C (PHOTO 14.10.82)

(b) DROP NO. 9. DART H (PHOTO 14.10.82)

(d) DROP NO. 7. DART A (PHOTO 14.10.82)

FIG. 17: KEMPTVILLE SITE 3 . EXAMPLES OF JACK PINE SURVIVAL.
DROP NO. 7, 29.4.82; NO. 9, 30.4.82 AND NO. 10, 3.5.82

(a) DROP ZONE (PHOTO 4.5.82)

(b) TYPICAL DARTS (PHOTO 7.5.82)

(c) DROP ZONE (PHOTO 20.10.82)

FIG. 18: PETAWAWA SITE ③ . SITE CHARACTERISTICS AND TYPICAL DARTS.
DROP NO. 13, 4.5.82; NO. 18, 7.5.82 AND NO. 20, 12.5.82

(a) DROP NO. 13. DART B (PHOTO 24.6.82)

(c) DROP NO. 20. DART A (PHOTO 13.7.82)

(b) DROP NO. 13. DART B (PHOTO 20.10.82)

(d) DROP NO. 20. DART A (PHOTO 20.10.82)

FIG. 19: PETAWAWA SITE 3 . EXAMPLES OF JACK PINE GERMINATION AND SURVIVAL.
DROP NO. 13, 4.5.82 AND NO. 20, 12.5.82

(a) DROP NO. 13. DART A (PHOTO 17.9.82)

(b) DROP NO. 13. DART D (PHOTO 20.10.82)

(c) DROP NO. 18. DART D (PHOTO 20.10.82)

FIG. 20: PETAWAWA SITE 3 . FURTHER EXAMPLES OF JACK PINE SURVIVAL.
DROP NO. 13, 4.5.82 AND NO. 18, 7.5.82

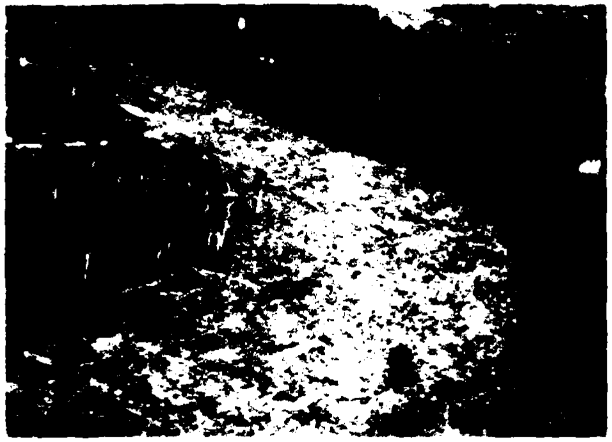
(a) DROP NO. 15. DART A (PHOTO 2.7.82)

(b) DROP NO. 15. DART A (PHOTO 20.10.82)

(c) DROP NO. 14. DART A (PHOTO 13.7.82)

(d) DROP NO. 14. DART A (PHOTO 20.10.82)

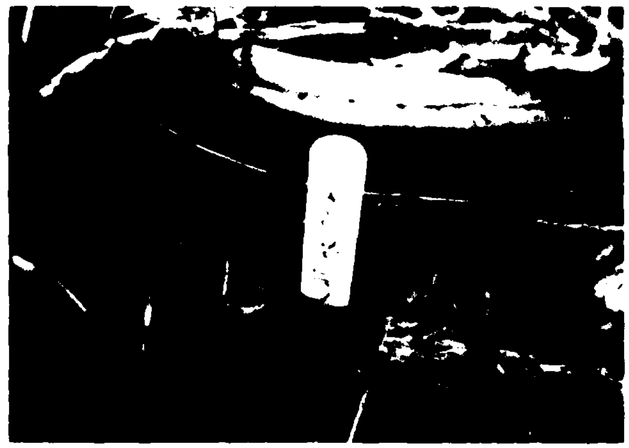
FIG. 21: PETAWAWA SITE ③ . EXAMPLES OF WHITE PINE GERMINATION AND SURVIVAL.
DROP NO. 14, 5.5.82 AND NO. 15, 5.5.82



(a) DROP ZONE (PHOTO 30.6.82)

(c) DROP NO. 51, DART B (PHOTO 22.10.82)

(b) DROP ZONE (PHOTO 14.6.82)

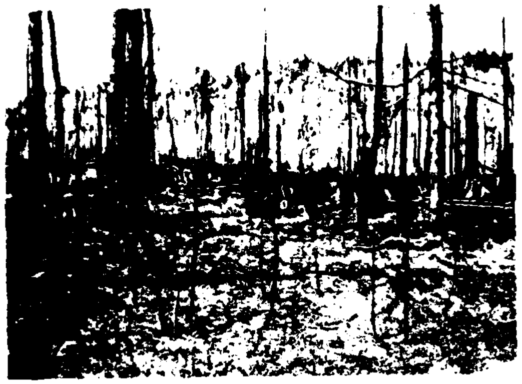


(d) DROP NO. 51, DART E (PHOTO 22.10.82)

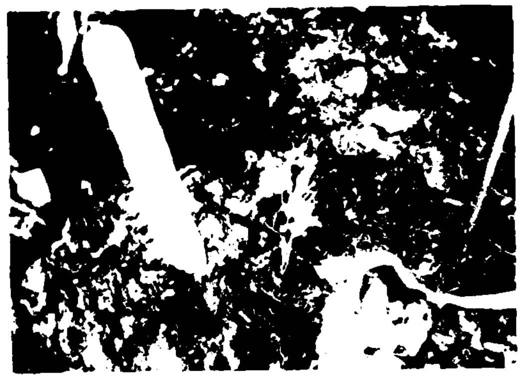
FIG. 22: MT. LAURIER SITE 2 . SITE CHARACTERISTICS AND EXAMPLES OF JACK PINE SURVIVAL. DROP NO. 51, 14.6.82

(a) DROP ZONE (PHOTO 3.6.82)

(c) TYPICAL DARTS (PHOTO 26.8.82)

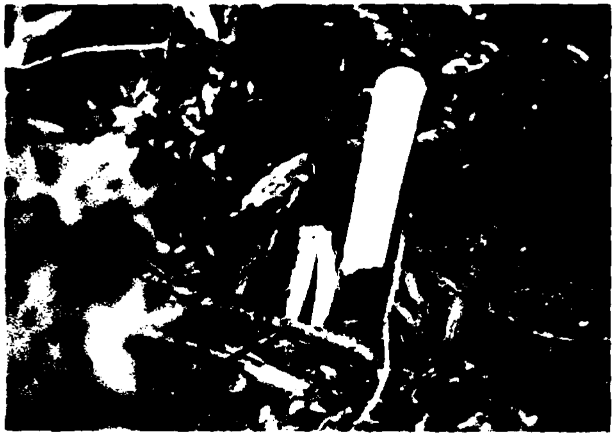


(b) DROP ZONE (PHOTO 3.6.82)

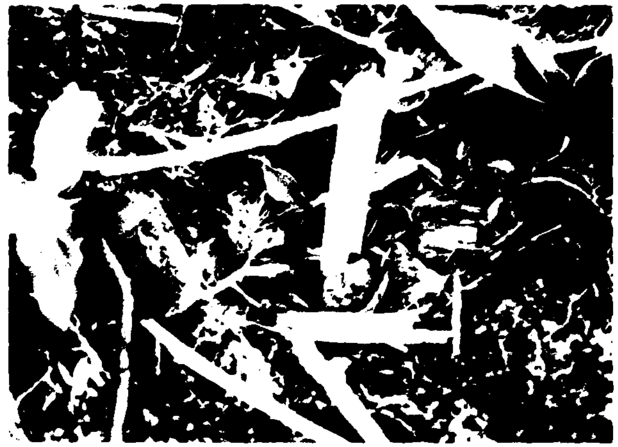


(d) EXAMPLE OF SURVIVING JACK PINE (PHOTO 26.8.82)

FIG. 25: AUBREY FALLS AREA SITE Ⓐ (1982 BURN). SITE CHARACTERISTICS AND EXAMPLE OF JACK PINE SURVIVAL. DROP NO. 35, 3.6.82.

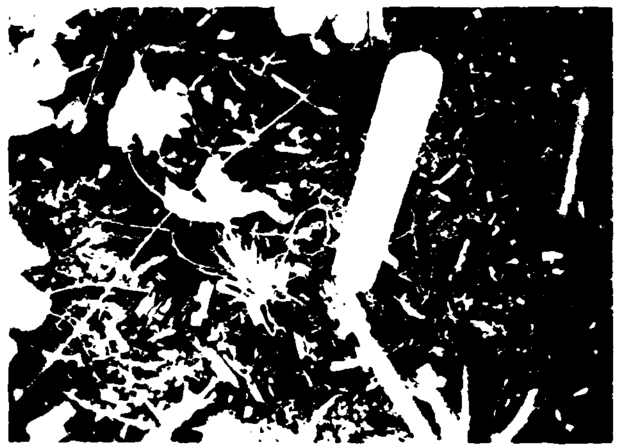


(a) EXAMPLE A (PHOTO 26.8.82)



(c) EXAMPLE C (PHOTO 26.8.82)

(b) EXAMPLE B (PHOTO 26.8.82)



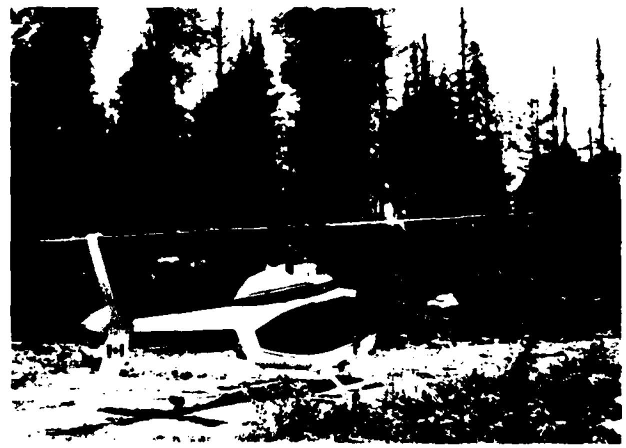
(d) EXAMPLE D (PHOTO 26.8.82)

FIG. 26: AUBREY FALLS AREA SITE (A) (1982 BURN). TYPICAL EXAMPLES OF JACK PINE SURVIVAL IN CONTROL-PLOTS. DARTS PLANTED MANUALLY 15.6.82

(a) SITE C, (SCARIFIED). (PHOTO 3.6.82)

(c) SITE E, (RESIDUAL TREES). (PHOTO 4.6.82)

(b) SITE B, (UNSCARIFIED). (PHOTO 3.6.82)



(d) AUXILIARY SITE, (RESIDUAL TREES). (PHOTO 4.6.82)

FIG. 27: AUBREY FALLS AREA. ADDITIONAL SITES IN JOINT GLFRC/NRC PROGRAM

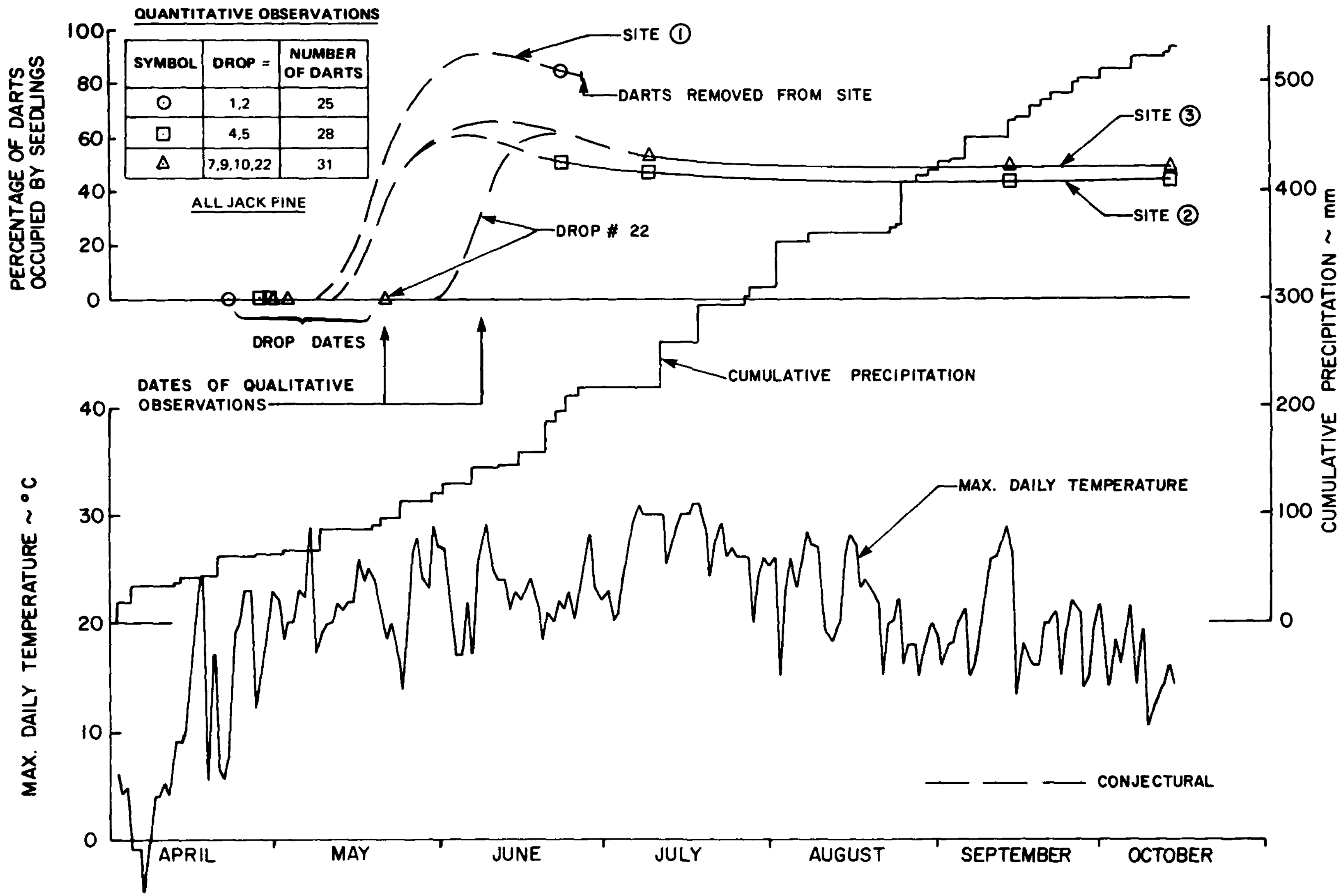


FIG. 28: KEMPTVILLE. SURVIVAL IN CANDIDATE DARTS

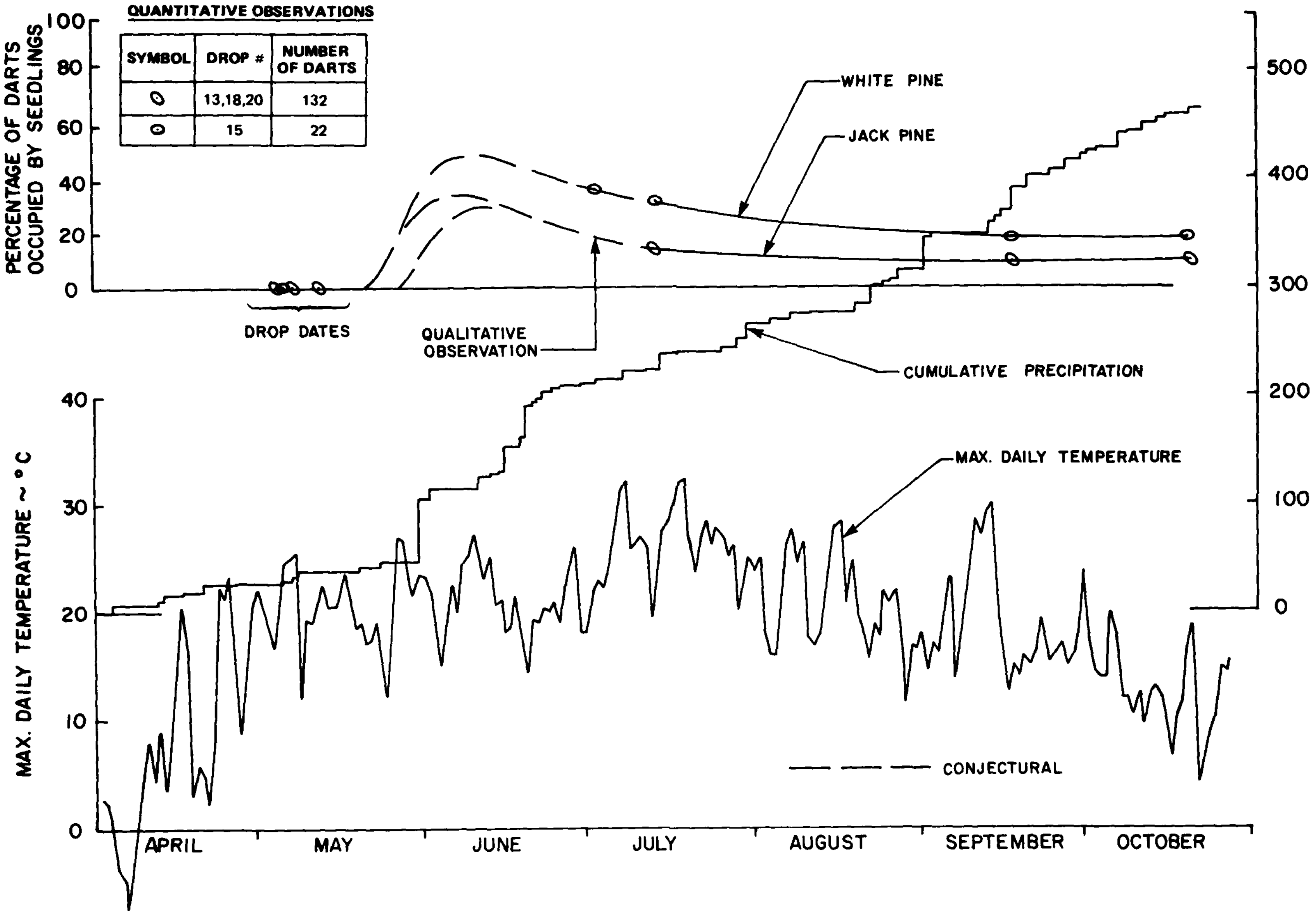


FIG. 29: PETAWAWA SITE 3 . SURVIVAL IN CANDIDATE DARTS

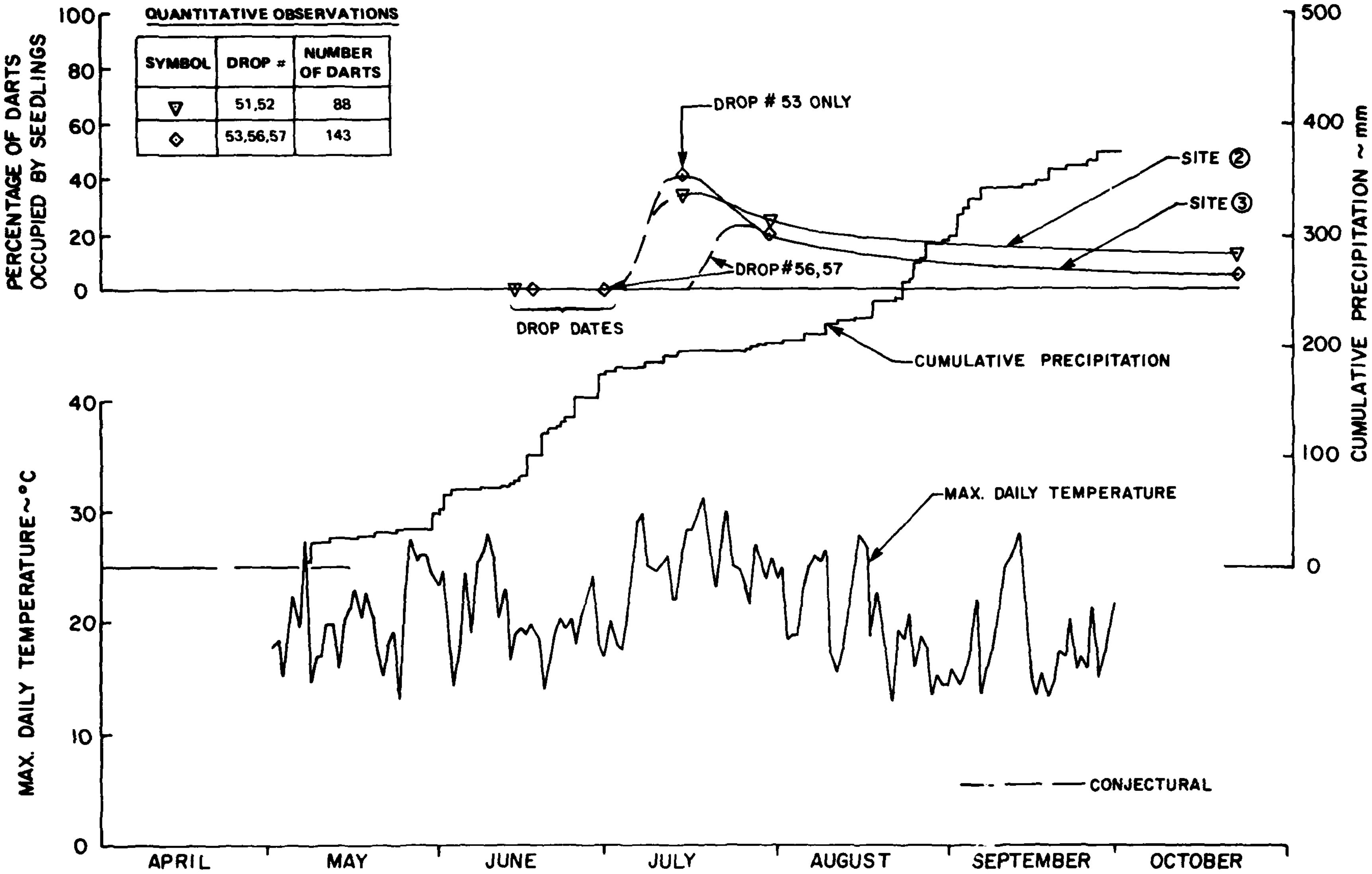


FIG. 30: MT. LAURIER. SURVIVAL IN CANDIATE DARTS

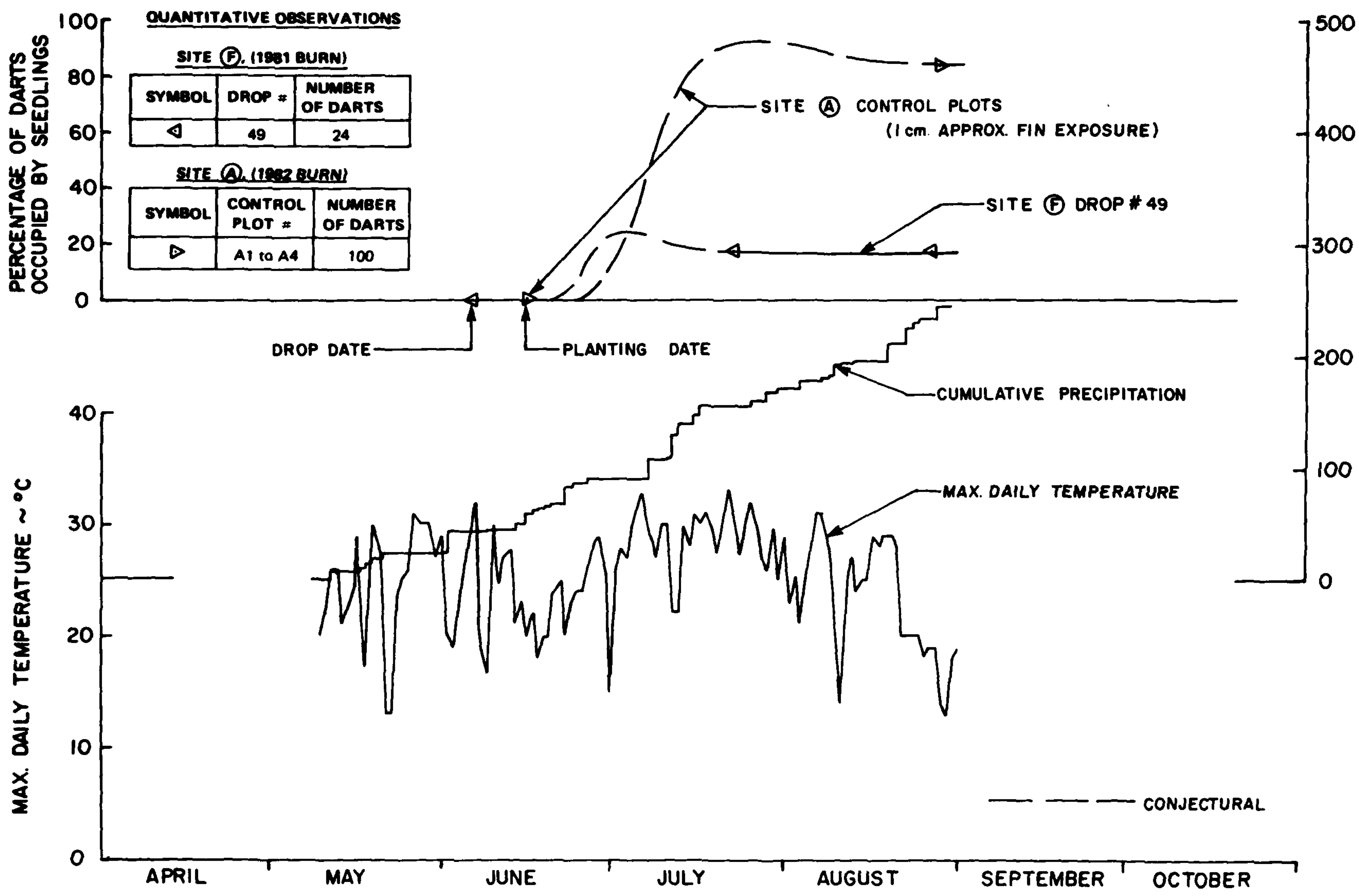


FIG. 31: AUBREY FALLS BURN SITES. SURVIVAL IN CANDIDATE DARTS

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NOTES

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SUMMARY/SOMMAIRE

The ability of aerial planting-darts to penetrate the ground and the subsequent survival of germinants have been investigated through airdrop tests conducted at various dissimilar sites.

The results indicate that there is a range of penetration within which darts may be considered as suitable candidates for the establishment of seedlings. Given some discretion in the selection of sites for aerial planting, it now appears reasonable to expect at least half the darts to achieve penetration within this range. The ultimate success, in terms of darts occupied by at least one surviving seedling, will then depend upon additional factors such as the depth of the mineral soil horizon below the ground surface, the presence of vegetation, the time of year and the prevailing weather.

Vigorous seedlings have been established by air-drops at some sites. Overall success rates are not, as yet, adequate, but the results have demonstrated the potential of the aerial planting technique and indicated some of the most promising avenues for further investigation and testing.

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